Trends and Techniques of Medical Image Analysis and Brain Tumor Detection

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Abstract

Image processing is adopted day by day by medical professionals for diagnostics and treatment of tumors. This application of engineering and technology is getting more and more space in the field of medical sciences. Various researchers across the world are working differently to explore the use of image processing in medical sciences and developed various algorithms and techniques to get more details like size, volume, and edges where tumors have been spread. In this paper, we have reviewed the various techniques which are carried out by different researchers in medical image analysis and brain tumor detection.

Keywords: medical image processing, brain tumor, diagnosis

INTRODUCTION:

Medical image processing is a rapidly growing and challenging field for researchers. The development of medical imaging techniques like x-ray MRC, CT scan, etc. led to a great advantage to diagnose and treat various internal diseases such as Tumor, Cancer, and internal deflects in various body parts. In medical images, the diagnosis of abnormal clustering of cells and tumor highly depends upon the experience of a medical specialist. Medical image processing aims to develop a new and accurate algorithm for the automatic detection of tumors and other abnormal entities. It aims to find not only the exact location of the tumor but also its size, shape, density, type, and boundaries. The development and progress of medical image processing from 1980 up to now, achieve many milestones but still, this research field has many unresolved difficulties and challenges. The image analysis community still needs to develop new, accurate algorithms and technologies to uncover information on the Molecular and cellular levels. No researcher has fully analyzed the variability in the requisition, equipment, used algorithm, and their interaction with a human operator to characterized whole information. Over the last 20 years, separate efforts have been made by researchers to develop a new algorithm and new principle to design an appropriate model for practical uses. It needs the formation of a common database where algorithms can be compared with each other. A major challenge is to develop appropriate validation and evaluation approaches between theoretical principles and practical utilization. Image segmentation has a vital role in image processing and the result of a proposed algorithm highly depends upon the segmentation process. There exist various pre-established segmentation techniques and their application for brain tumor detection. The development of new segmentation techniques in the last decade enhances the hidden information in medical images. A brain tumor is successfully and accurately segmented by these algorithms which help to auto-diagnose of brain tumors but for practical and real-time applications more research is required. Medical image analysis involves, image pre-processing segmentation and post-processing. For pre-processing there are various filtering techniques available, the median filter is most commonly used due to its ease and efficiency in removing salt and paper noise. Gaussian filter is useful in smoothening Gaussian noise. Sobel filter is better for edge preservation. In the segmentation process, thresholding is good for the initial stages but not useful for the extraction of much relevant information. Fuzzy C-means and K-means techniques required less human interaction and were useful in poor contrast images.

MATERIAL AND METHODS:

Michael R. Kaus et al. used automated segmentation of MRI of brain tumors with a template-driven segmentation-based algorithm. The automated segmentation of MRI of 20 patients with meningiomas and low-grade gliomas was tested and measure against manual segmentation. The findings of this work show that meningiomas and low-grade gliomas can be accurately and reproducibly auto-segmented. However, the validity of segmentation is difficult to assess in the absence of a standard automated segmentation method that has high accuracy within the maximum difference of 0.6% of manual segmentation. The size of the abnormal structure affects the accuracy of segmentation. Because segmentation error occurs on the boundary of the surface, therefore, larger surface led to more miss segmentation. Hence accuracy is less with large objects compared to smaller objects. The automated method has higher reproducibility hence compared to manual segmentation, it does not reduce inter-observer variability substantially. Under restriction to ICC, In the area of interest, the tissue which shows single intensity overlap with the meningioma was excluded and meningioma segmented successfully. So accurate segmentation is possible for low-grade gliomas and meningiomas with automated methods but further work is required for practical use and clinical testing [1].

Mathematical morphology and curvature evaluation based algorithm proposed by Frederic zona and Jean-Claude Klein for detection vessel-like patterns in noisy image or environment, to separate vessels from the background, a cross-curvature evaluation is performed and these vessels have specific Gaussian-like profile. Morphological operators like erosion, dilation, opening, closing top hat, etc, are defined and utilized for the recognition of geometrical features of the image object. The evaluation of curvature is obtained by using Laplacian. The proposed algorithm was tested on a database of nearly 200 angiographies of patients with different abnormalities. The algorithm proposed by the scientist for the detection of the vessel-like pattern is useful in a wide range of retinal images and it also can be used in fields like segmentation of reads[2]

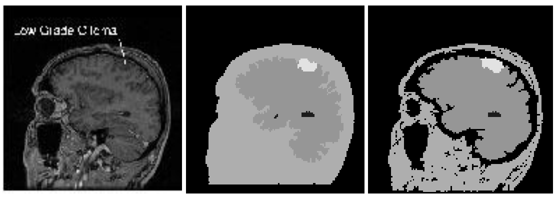

Fig.-1: Example of manual and automated segmentation of low-grade gliomas: SPGR image (a), Manual (b), and template moderated segmentation (c), Micheal R.kaus et al, Automated segmentation of MR Images of Brain Tumor", Radiology 2001, 218: 586-591[1].

In a paper by Zhao Yu-Qian et al., basic morphological operators were introduced and a novel morphological edge detection algorithm for detecting the edge of lungs in CT images with salt and pepper noise. According to the outcome results of the work, they concluded that the proposed algorithm is more efficient than template-based edge detecting algorithms such as Sobel edge detector, morphological edge defector, etc. [3].

Mathematical morphology methods used by Akara Sopharak et al. for auto-detection of diabetic retinopathy exudates from non dilated retinal images. In a diabetic patient, exudates occur when lipid or fat leaks through abnormal blood vessels. The proposed algorithm was tested on 60 images and the results of exudates detection were superimposed on original images. The results show that those exudates regions were visibly highlighted which are not clear before processing. The results were evaluated quantitatively against extractions of the ophthalmologist and it is found that the technique is sensitive and has accuracy. Therefore a practical system based on this technique can reduce ophthalmologist workload and also provide quick detection of exudates which is helpful for fast and rapid treatment[4].

Ahmed Kharrat et al. uses mathematical morphology to increase contrast in MRI images, after that wavelet transform is utilized in segmentation and the K-means algorithm is implemented for detection and extraction of Brain tumors. The proposed methodology is practically used for the extraction of the tumor and the result of real-time work is significantly concordance comparing with the expert's result. However, the classification of the brain tumor as "benign" or malignant is the subject of future research [5].

a)	Cerebral image MRI
b)	Contrast enhancement of image by mathematical morphology algorithm
c)	Wavelet transform decomposition
d)	Tumor extraction by K-means unsupervised classification method
e)	Satisfying classification
f)	Maling OR Benign

Fig.-2: Steps of the algorithm, Ahmed Kharrat et al, Detection of brain tumor medical images", IEEE, international conference on signals, circuits and system 2009[5].

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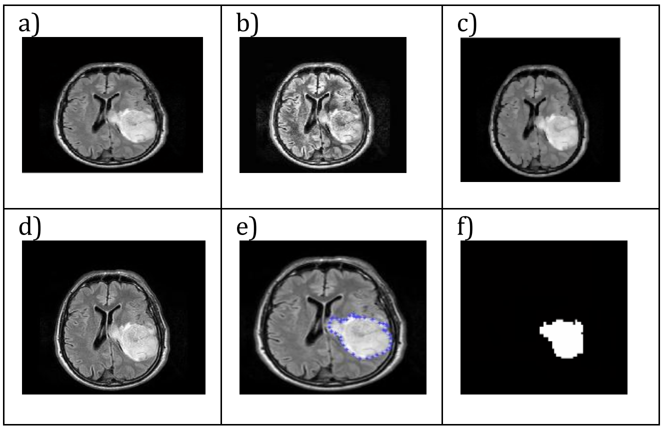

Fig.-3(a) original image (b) CLAHE (c) Beghdadi (d) Mathematic Morphology (e) expert selection (f) K-means selection. , Ahmed Kharrat et al, Detection of brain tumor medical images", IEEE, international conference on signals, circuits, and system 2009[5].

T. Logeswari and M. Karnan perform brain tumor detection by using a soft computing segmentation technique. In this work, a Hierarchical self-organizing map (HMOS) is used for brain image segmentation and target area (brain tumor) segmented and detected successfully [6].

An integrated approach of K-means clustering and fuzzy C-means clustering both integrated with the marker-controlled watershed algorithm for segmentation of medical images was proposed and compared by M.C. Jobin and R.M.S. Parvathi. K-means clustering with a controlled watershed algorithm gave a better result than Fuzzy C-means clustering with a controlled watershed algorithm. Therefore no single method is sufficient for all kinds of images [7,13].

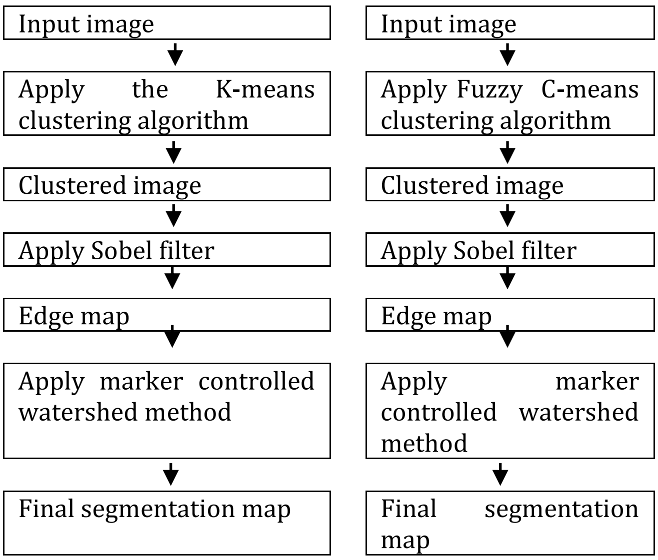

Fig.4: Flow chart of the used method, M.C.Jobin et al., Segmentation of medical image using clustering and watershed algorithm". American Journal of applied sciences 8(12): 1349-1352, 2011.[7].

The operators of mathematical morphology were discussed and used by Hu Jiang-Hua et al., to eliminate sharp angles and small spots in the dominant color images. It also enhances the consecutiveness of dominant color spots and expands the area[8].

Subhranil Koley and Aurpan Majumder, work out to segment brain tissues and tumors by using CSM based K-means algorithm for detecting the location of the brain tumor in MRI. The proposed algorithm is efficient for segmentation with less computational complexity compared to other methods. The suggested method does not provide efficient results where the tumor is surrounded by edema therefore to remove such problems more future work is required[9].

Leela G.A. and H. Veena Kumari use K-mean and Fuzzy means clustering algorithm for segmentation to detect brain tumor and cancer cells in a medical image. The detection of the boundary of the tumor depends upon the segmentation algorithm. According to this study, both segmentation methods produce efficient results and use full for Artificial diagnosis of abnormalities like brain tumors in medical images [10].

A novel approach for generating AUHB-DW image by applying the concept of HCRF proposed by Mohammad Javed et al. In their study, they point out that the proposed AUHB-DWR algorithm has improved reconstruction quality and improved intensity delineation than existing AUHB-DWR methods [11].

To enhance the contrast and quality of medical images, various morphological transform operations carried on medical images like top-hot and bottom-hot transform, generally, a disk-shaped mask used in these transforms. Raihan Firoz et al. takes a mask of arbitrary size and keep changing its size until an optimum enhanced image. The result of this work shows that the proposed method improves the contrast of medical images which can help in better diagnosis [12].

Devendra Somwanshi et al., compare and analyze various threshold entropy-based segmentation methods through simulation results. Entropy methods like Renvi, Vaida, Shannon, Kapar, and Havrda – Charvat are applied for brain tumor detection and results of various methods compared with each other. Analysis and comparison of results show that Havrda – Charvat entropy method performs better than any other entropy algorithm [13].

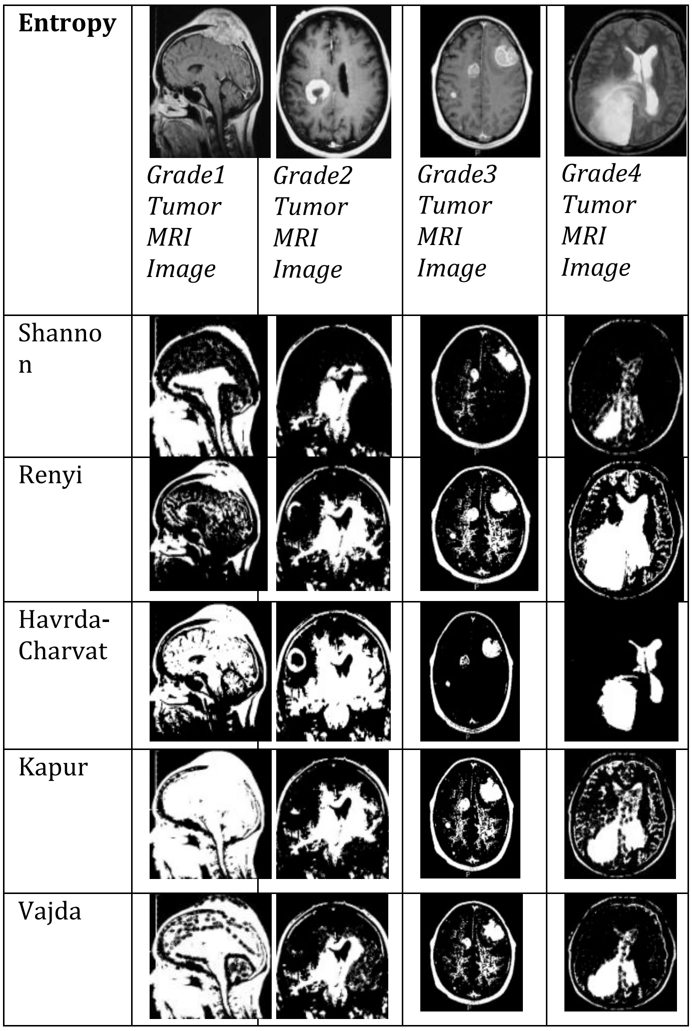

Fig.-5: Result of different images processed with various entropy methods, Devendra Somwanshi et al., Än efficient brain tumor detection from MRI images using entropy Measures", IEEE International conference of recent advances and innovations in engineering Dec. 23-25. Jaipur, India, 2016[13].

Swapnil R. Telrandhe et al. proposed a method for brain tumor detection using K-means segmentation with preprocessing of images and using object labeling for more detailed features of the tumor. Support vector machine (SVM) tool used for data analysis and classification. The area of tumor and type of tumor find by this method and future work involves, determining the size, volume, and stage of the tumor [14].

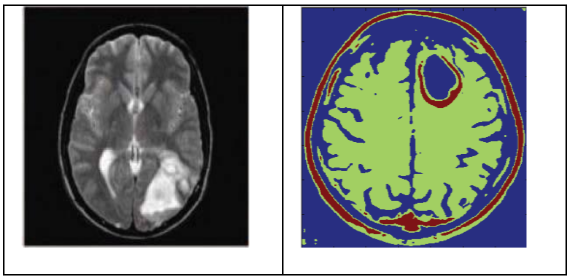

Fig.-6 :(a) Original image (b) segmentation resulted in the image, Swapnil et al., Detection of brain tumor from MRI images by using segmentation and SVM", IEEE world conference on Futuristic Trends in research and innovation for social welfare (WCFIR'-16), 2016[14].

Hao Dong et al. proposed a completely automatic method for brain tumor segmentation based on the U-net deed convolutional network. The proposed method was applied and tested on a multimodal dataset having 220 high-grade and 54 low-grade tumor cases. Results of the proposed method are comparable to other states of the art methods for all tumor regions, therefore, the proposed method is reliable for diagnosis of tumor and treatment planning [15].

Mohammad Havaei et al., introduce traditionally different CNN architecture which exploits local features as well as global contextual features commonly. A 2-Phase training procedure was used which allows us to overcome difficulties related to the imbalance of tumor labels. Results of the proposed method of evaluation from BRATS 2013 confirm that used method to improve accuracy and speed. [16]

A method consisting of initial segmentation modeling of the energy function and optimization of the energy function, introduced by C.Hemasundara Rao et al. Conditional random field (CRF) based framework utilized to combine information present in T1 and FLATR MRT images. A CRF-based framework is useful for modeling complex shapes easily. The proposed method for Brain Tumor detection and segmentation. Incorporates additional information present in T1 – weighted. Therefore its performance is finer in the presence of artifacts and improves the boundaries of the tumor. [17]

CNN Method of segmentation has a lack of image-specific adjustment and ratiocination of previously unseen object classes. To address these problems Guotai et al. proposed a novel deep learning-based interactive segmentation framework of integrated CNNs into a bounding box and scribble-based segmentation pipeline. The result shows that the proposed method performs well on the previously unseen object and takes less user time than the traditional segmentation method. [18]

Ozan Oktay et al., propose a generic training policy that integrates anatomical prior knowledge into CNNs through a new regularization model. In the proposed method, autoencoder (AE) and T-L networks are used to train the neural network. The experimental result shows that the proposed model benefit in cases where the image one corrupted and contains artifacts, and have the future scope in other image analysis field. [19]

Mahesh Swam and Divya Verma proposed a method based on a morphological operation of erosion, denoising, and thresholding based tumor segmentation for the detection of a brain tumor in CT and MI images. The database was taken from google open-source and practical work carried on Mat LAB-2019 software. The proposed method achieved a sensitivity of 100%, the similarity of 89.667., an accuracy of 87.50%, and claimed to be a cost-effective system accessible to medical practitioners on everyday computers. [20]

A novel two-stage framework named spine presided to execute automated spine parsing for volumetric MR images. The method consists of a 3D graph conventional segmentation network for 3D coarse segmentation along with a 2D residual U-Net for 2D segmentation refinement. The practical results on Y2-weighted volumetric MR images of 215 subjects show an impressive performance with mean dice similarity coefficients of 87.32 ± 4.75%, 87.78 ± 4.64%, and 87.49 ± 3.81% for segmentation of vertebrae, 9 IVDs, and all 19 spinal structures respectively. [21]

In MRI images, identification of brain tumors is done by using the GUI framework. Prewitt horizontal edge strengthening filter used for filtering the image and "watershed pixels" to identify the tumor. The GUI method helps one to adjust the parameters without updating the software and provides much better results than standard tumor detection techniques. [22]

CONCLUSION:

Medical image analysis is an emerging and challenging research field that has a direct social impact and benefits. It is very helpful for quick diagnosis and treatment, especially in developing countries where the doctor-patient ratio is poor.

Medical image analysis includes the acquisition of images, pre-processing, segmentation, detection, analysis, and diagnosis. In the image, analysis segmentation plays a vital role and in recent years various segmentation algorithms like the K-Means method, Fuzzy logic, Neuro-Fuzzy, Neural network, Snake algorithm, Thersolding based algorithms have been developed. Each of these methods has some advantages and some limitations. Different analysis techniques have a different degree of accuracy in different cases therefore practical sensitivity is also an issue. All these techniques and algorithms demand a common & universal stander or protocol so that the accuracy, validity & limitation of these techniques can be compared. A comparative study of all algorithms is also required to develop a standard practical model of real uses. This field requires more research work and a common approach to developing a standard model for auto-detection and diagnosis.

S.No.	Researcher	Technique/ Methods	Aim	Result
1-	Michael R. Kaus et al.	Adaptive template – Moderated classification	Auto segmentation of brain tumors in MRS	The proposed method of auto – segmentation of meningioma and low grade glioma has mean accuracy of 99.68% ±0.29(SI) for all 20. Cases. Intra observer variability is 0.10% - 3.57% and 0.14% - 4.70% Inter observer variability is 0.33% - 4.72% and 0.99% - 6.11%
2-	Frederic Zana and Jean – Claude Klien	Mathematical morphology and curvature evaluation	Segmentation and detection of vessel-like patterns in a noisy environment	The proposed algorithm is useful in a wide range of retinal images and also in the segmentation of roads and other fields.
3-	Zhao Yu-Qian et al.	A novel mathematical morphological edge detection algorithm	To detect the edge of lungs CT image with salt and paper noise	The used algorithm is more efficient in medical image denoising and edge detection compared to template-based edge detector, Gaussian operator, Sobel edge detector gradient operation, and dilation residue

				edge detector.
4-	Akaro Sopharak et al.	Mathematical morphology methods	Auto-detection of diabetic retinopathy exudates from non-dilated retinal images	The result of the used algorithm shows that those exudates regions were visibly highlighted which are not clear before processing and the technique is found to be accurate and sensitive against the extraction of ophthalmologists.
5-	Ahmed Kharrat et al.	Mathematical morphology used to increase contrast in MRI image wavelet transform in segmentation and K-means algorithm for extraction of Tumor	Detection of Brain Tumor in medical image	The introduced algorithm reduces the extraction steps. The final result of the work is that it extracts the tumor region and the outcome significantly agrees with the expert's result. However benign and malignant nature of the tumor is the subject of future work.
6-	T, Logeswari and M. Karnan	Soft computing based segmentation and Hsom Vector quantization	Improved auto-detection of Brain Tumor	The suspicious region or Brain Tumor is segmented and extracted successfully by using a Hierarchical self-organizing map.
7-	M.C. Jobin Christ and R.M.S. Parvathi	Integrated Fuzzy C-clustering and K-Clustering with marker controlled watershed segmentation algorithm	Segmentation of medical images	Integrated K-Means clustering with marker-controlled watershed algorithm gave better segmentation compared to integrated C-means clustering with a marker-controlled watershed algorithm.
8-	Hu Jiang- Hua et al.	Mathematical morphological operator, erosion dilation, HMT	To improve the multicolor image and eliminate sharp angles in camouflage.	Used morphological operator significantly improve multicolor image, reduced sharp angles, and small spots in a dominant color image.
9-	Subhranil Koley and Aurpan Majumder	CMS based partitional K-Means algorithm	Brain MRI segmentation for tumor detection	The proposed method is simple and efficiently segment brain MRI however it does not provide efficient results in the case where brain tumors are surrounded by edema.
10-	Leela G.A. and H.M. Veena Kumari	K-means and Fuzzy C – means Clustering	Detection of brain tumor and cancer cells.	The tumor segmented with K-means clustering is faster and shows tumor boundaries more accurately compared to tumor segmented by fuzzy C- means clustering.
11-	Mohammad Javad Shafiee et al.	AUHB – DWR algorithm HCRF and HSFCRF.	To improve image quality and repairability between tissue.	Proposed AUHB- DWR methods improve reconstruction quality and improve intensity delineation.
12-	Raihan Firoz et al.	Morphological transforms	Images enhancement	The used method enhances the contrast of medical images.
13-	Devendra Somwanshi	Threshold – Entropy-based Segmentation methods	Brain Tumor detection in MRI images.	Havrda Charvat Entropy method is the best and accurate among other entropy methods.
14-	Swapnil R. Telrandhe	K- means algorithm Labeling algorithm and SVM.	Extraction of brain tumor from MRI	Tumor Area and its type extracted successfully. The tumor size and stage of the tumor is the field of future work.

15-	Hao Dong et al.	Li- Net-based fully convolutional network	Automatic brain tumor detection and segmentation	The proposed method produces an efficient and robust segmentation of tumors compared to manual methods.
16-	Mohammad Havaei et al.	Deep Neural Network	Brain Tumor segmentation	High performance was achieved with the help of a novel two pathway architecture.
17-	C. Hema Sundara Rao et al.	Conditional random field	Brain Tumor detection and segmentation	The proposed method shows promising results and improves the boundaries of the tumor.
18-	Guotai Wang et al.	Deep Learning with image-specific fine-tuning	Accurate and robust image segmentation	The used method performs well on the previously unseen object in an image and takes less time.
19-	Ozan Oktay et al.	Anatomically constrained Neural Networks	Cardiac image enhancement and segmentation	The proposed model is useful for corrupted images and contains artifacts.
20-	Mahesh Swami Divya Verma	A method based on the morphological operator of erosion, denoising, and thresholding based tumor segmentation method	To detect brain tumors in CT & MRI by using image filtering and segmentation method	An accuracy of 87.50% sensitivity of 100% and 89.66% similarity was achieved by the proposed method.
21-	Shuma pang et all	The spine parse net consisting of GCSN and ResUNet based method	To achieve spine parsing for volumetric magnetic resonance images.	An accurate spine parsing for volumetric MR images achieved by spine parse net method and has area + potential in diagnosis and treatment of spinal disease.
22-	G Bhargavi, J.agril Robinson, et al.	Brain tumor detection from MRI images by using Prewitt horizontal edge-emphasizing filtering technique	Brain tumor detection in MRI images	The proposed method achieves much better results than standard tumor detection techniques.

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